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THE TREND OF AVIAN POPULATIONS IN CALIFORNIA

THERE is one besetting temptation to which any student fairly advanced in the exploration of his chosen field would seem justified in yielding. This temptation is to hold up to close scrutiny any striking generalization given wide publicity, save it be from the most authoritative source—to see whether it be really founded in fact. A case in point has to do with avian populations.

It has been stated or at least implied with increasing frequency in late years, in various publications, especially in those emanating from organizations concerned with bird protection, that serious decrease is taking place in our bird life, and that this decrease is due to the thoughtlessness or perfidy of man and is preventable. These statements and implications are being expressed not only with regard to the longer and more thickly settled eastern United States, but with regard to the west in general, and to California. Confessedly with some *a priori* doubt, but with a view to testing fairly the truth of these dicta, I have undertaken an inquiry into the situation in our own state, for the purpose of finding out what the facts are—of ascertaining whatever changes in our bird population may, indeed, have become apparent, and the causes therefor.

To begin with, of course, terms must be defined. In using the word "decrease," or its opposite, "increase," in this connection, one of two distinct ideas may be in a person's mind. He may refer to the *number of species,* or he may refer to the aggregate *number of individuals.* Or, both of these ideas may be held, in more or less vague association.

To take up the first concept: There is no question whatsoever that a certain few species of birds have become nearly, or quite, extinct, as far as California is concerned, within the

past seventy-five years; as examples, the trumpeter swan and the whooping crane. But, compensating for these losses, there have become newly established within our territory during that same period some species of foreign source; as examples, ring-necked pheasant and English sparrow. Checking up the species of both categories, we can reach but the one conclusion that, as yet, so far as concerns the state as a whole, there has been no real reduction in the total number of species; our known avifauna at the present moment totals 582 species and subspecies; I am aware of no good ground for supposing that it was one unit more or less, seventy-five years ago.

If, however, we narrow our attention to given restricted localities, we are confronted with evidence of real and great reduction in species, up to even forty per cent. of the original number, I figure, in some places. It is this *local* reduction in species, most apparent naturally in centers of human population, that has impressed so strongly the ardent advocates of the various sorts of bird protective measures.

An entirely different phenomenon, as already intimated, is comprised in the fluctuation of aggregate populations, irrespective of the various species, few or many, represented in them. On this point, my impressions are strong that, throughout the country at large, wherever human influence has had any marked effect, there has been *increase* in the bird life. In some localities, as pointed out below, this increase may reach as much as tenfold.

My reader will at once demand something more tangible than "impressions." And I am compelled regretfully to admit that actual figures seem to be wanting. We have no record of censuses taken fifty years ago, or even twenty-five years ago. This is unfortunate; and it is to be hoped that further lapse of time will see an improvement in this situation. Numerical censuses, on either an areal basis or a unit-of-time basis, are now being taken and recorded. The student of the future, let us hope, will have plenty of statistical data upon which to base final conclusions.

It seems, then, that, in this discussion, I must fall back upon less tangible classes of evidence—upon memory and upon inferences from other categories of facts. Before citing this evidence, however, let me introduce some theoretical considerations.

It is a recognized, established principle that the presence in a region of any given bird species is absolutely dependent upon, first, proper food supply, second, the right kind of breeding places, and third, appropriate cover or protection for individuals—each of these conditions as bound up with the inherent structural features of the bird under consideration. Mark that there are *three* of these factors, each and all of them essential; if any one of them in a given region becomes effaced, the bird in question can no longer exist there. There are, of course, other factors essential to avian existence, but they affect all the birds of a given fauna alike. We can deplore, wring our hands, and suffer agonies of regret, but to no avail—except as active steps be taken to restore the critical condition. As a matter of cold circumstance, a bird's disappearance in a given locality may be irretrievable—as happens where man has densely settled a territory and incidentally or purposely destroyed certain of its natural features unnecessary or inimical to his own existence there. Chop down all the trees and there can be no more woodpeckers; drain the lakes, ponds and swamps and there can be no more water birds; remove the chaparral, and wren-tits, bush-tits and thrashers can no longer find proper food and shelter. Cement up all the holes in the campus oaks and there will be no more plain titmouses—for the reason that roosting and brooding places essential to their existence are no longer to be found.

Each bird species native in a given region has a different and very special combination of requirements. Existence of each is really determined by a very slender thread of circumstances which can, in most species, be broken readily. Differences must, of course, be recognized in the degree of hardihood, or of viability, in the various species of birds—some are on the ragged edge of extinction, this condition in part due to inherent reduction in specific vigor—the race is naturally playing out, we say; others are hardy, with a large reserve

of specific energy; some can even stand what may aptly be called ecologic punishment.

In any one locality the field observer comes to recognize a few or many rather intangible units which he calls "ecological niches"—separate cubby-holes or dwelling places or habitats (in the narrowest sense), which differ in essential respects from one another. If the topography and vegetation be varied, there are many of these niches; if more uniform, there are few of them. Each niche is separately occupied by a particular kind of bird, and the locality supports just as many species of birds as there are niches; furthermore, the numbers of individuals of each bird are correlated directly with the degree of prevalence or dominance of the niche to which that particular bird is adapted. In other words,—and here is the crux of the idea,—both the number of the species and the number of the individuals of each species, in a locality, are directly dependent upon the resources of the environment, from an avian standpoint. The same notion holds, of course, for all other animals, including *Homo*.

Rate of reproduction in any species has been established down through past time so as to supply the population needed to keep the appropriate niche filled. This rate varies with the natural prevalence of the niche, and with the hazards to which the niche occupant is exposed. Not only that, but a wide margin above the normal need is provided to meet that extreme emergency which may arise but once in a thousand generations; in other words, there is produced a large surplus—an apparent great waste—of individuals over and above what is needed to keep the appropriate territory fully populated, in order to save the species from extinction at some critical moment; for animate nature abhors a vacuum no less than does inanimate nature. A recent writer in SCIENCE (LV, May 12, 1922, pp. 497-505), Professor A. F. Shull, has, in another connection, called this fact of over-production the "factor of safety." He says: "The entire struggle for existence is based on the principle that security and advancement are best assured through wasteful over-production." The employment of the factor of safety, I would say, is a manifest device on the part of nature to insure continuity of species, and hence also to make evolution possible.

A British ornithologist, Mr. H. E. Howard, has lately put out a book in which he elaborates exhaustively the idea of the importance of territory to bird life. Kind and availability of territory determine the kind and amount of bird life. In final analysis, when a territory, or, as I would express it, more explicitly, an ecological niche, becomes *full,* and this in normal times comes to pass very quickly, the individuals within the species constitute each other's worst enemies. Continued conflict for space—for a piece of land, for an area of meadow, for a section of tree-trunk, for a given unit of volume of twiggery or foliage—is plain to be seen by any diligent observer of bird life. The resulting pressure for territorial expansion reminds one of the same pressure obtaining among humans; only, among birds, there is no organized warfare. The process is one of struggle as between individuals or pairs of individuals, between neighbors, indirectly, perhaps, as a rule; but also, often, directly, by personal action. The most fit to compete, sometimes the most fortunate, will survive; the less fit will be eliminated. The survival prospects of each single individual are small. Vast numbers of individuals are poured in. The "safety factor" in numbers is there in order to insure the persistence, and continued adaptive improvement, *of the species.*

Let us now return to more matter-of-fact considerations. What have been some of the effects of the settlement of California by the white man, upon the environments of birds? Have any ecological niches been effaced? Have any niches been added? Have some been reduced in prevalence and others increased in prevalence, relatively? What have been the effects upon the niche-occupants?

Perhaps the most conspicuous changes wrought in the appearance of the landscape in the southwest have resulted from irrigation. In substantiation of this statement, many of my readers can doubtless appeal to his own memory. I, myself, recall traversing long

stretches of the San Joaquin Valley twenty-five years ago, which were then merely arid plains. The vegetation consisted of xerophilous grasses and herbs, with here and there tracts of lupine or atriplex bushes. The birds observed were scattering horned larks, fewer meadowlarks, and occasional burrowing owls; it being winter, there were more numerous Savannah sparrows and, in rain-dampened places, pipits. Knowing what I do now about censuses, I doubt if there were then more than one bird to the acre, on an average, probably much less than that ratio.

Now, regarding the same territory, it would be hard to exaggerate the amount of change in vegetation which has resulted from the watering of the ground. Orchards, alfalfa fields, green pastures and streams of running water lined with willows, completely occupy the land. Instead of a very uniform type of environment, with only a few niches and correspondingly few species of birds, one finds, upon analysis, a great variety of niches and a much increased number of bird species. What is more, the numbers of *individuals* are vastly larger. To be sure, the horned larks and burrowing owls are gone. But the meadowlarks have multiplied; and, in addition, one sees great numbers of Brewer blackbirds, of mockingbirds, goldfinches, swallows, phœbes and killdeers. I esitmate the mean population over large areas of the San Joaquin in April, when the lowest ebb for the year is reached, at 10 per acre, or over 6,000 per square mile. Here, obviously, the conditions for abundant avian population have been markedly improved by the coming of the white man with his methods of cultivation.

Even more spectacular has been the faunal change wrought by irrigation in Imperial Valley, where luxuriant vegetation with resulting abundance of bird life has replaced the original sparse vegetation of the desert which supported relatively little animal life.

Another biotic modification is brought about by deforestation. Close stands of coniferous trees are replaced by "slashes," by open young growths, or by mixed brush land and trees. Dense forests, it is well known, are sadly lacking in bird population. The removal of the forests has meant, of course, the disappearance of a few, specialized avian tenants. But in their place, occupying the clearings and mixed growths, is a much greater population both as to individuals and species. Kinglets, pileated woodpeckers, and hermit thrushes may have disappeared; but fox sparrows, chipping sparrows, spotted towhees and a host of other birds of like habitat preferences have come in. Certain little niches have been done away with; but the change in the nature of the territory at the hand of the lumberman has resulted in there being many more, new niches; each of these, evidently, of greater amplitude, of greater supporting power.

Very definite change in the other direction has been that made as a result of the draining of swamp lands. Many species thereby have been eliminated, locally, many more species than occupy the reclaimed land; and, furthermore, I feel sure that the numbers of individuals, too, have been reduced, though not in so large proportion. As instances, I would refer to Nigger Slough and Gospel Swamp in southern California, and to the region at the confluence of the Sacramento and San Joaquin Rivers in west-central California. A swamp is really a very complicated type of environment; within it usually may be recognized *many* "niches" and a correspondingly large number of avian occupants. Among these are the herons, rails, gallinules, song sparrows, yellowthroats and tule wrens, and, if there be open water, coots, terns and several species of ducks.

The most serious adverse effect of the human occupancy of California upon bird-life thus far has, I believe, resulted from this reclamation of the swamp lands. But, if you will resort to memory, or examine a topographic map, you will observe that the total area here involved is very small compared with the territory that has been affected oppositely, by irrigation. Irrigated territory, moreover, is subject to continual and much farther spread, while the possibilities of drainage are almost exhausted.

Other modifications of primitive conditions as a result of the white man's occupation of

the country are as follows: By the clearing of brushlands, for example, in San Fernando Valley, Los Angeles County; by the planting of trees, afforestation, as exemplified in the groves of trees around the Greek Theater and on the Berkeley hills; by the cultivation of dry grasslands, as on the coastal benches of San Diego County; and by the formation of storage reservoirs and canals, which, irrespective of the lands which they water, bring into existence aquatic and riparian types of vegetation conducive to an abundant bird life. Some of these it will be noted, check against one another, so that *status quo,* in part of the country, tends in some measure to be maintained.

In general, then, my contention is that there has been, on the average, as a result of the settlement of California, a marked increase in our bird population. Bird life at large has benefited—and this in spite of various adverse features which also have been imposed. My message should be, therefore, one of optimism to the bird-lover. It is to be understood that I refer to birds of all groups together; not to any particular group. There are vastly more of the so-called "song birds," numerically, than there are of the "game birds" and "birds-of-prey." The latter two groups have been seriously depleted, unquestionably, from various causes associated with man; but probably not more than ten per cent. of our original bird population consisted of game birds and birds-of-prey combined.

Permit me now to link up with current notions and beliefs in regard to the status of bird life some of the ideas that I have been endeavoring to express. In a large proportion of cases the reduction or disappearance of a cherished species of bird, locally, such as may have been laid to other entirely different causes, has really been due simply and inevitably to the reduction or complete effacement of the kind of habitat the bird must have for its existence; in other words, its ecologic niche has been reduced in volume, or destroyed. No one could help it; nor can any one now stay the process, except by restituting the lost factor; for example, when land is bought or otherwise preserved from human use and devoted to the use of the birds, as in national or state bird or game reserves. Of course, in certain areas, such as national parks and forest reserves, the environments and the birds occupying them are being preserved anyway, incidental to other interests.

The tendency among sentimentalists has usually been to seek out a cause for the disappearance of birds that is directly concerned with their fellow men. The hunter, the boy with the sling shot, the collector, any one of them or all, loom up as *the* "exterminators of birds"; whereas, in truth, I believe, it is only in rare cases and then only very locally, that *these* agencies have had any effect at all. In other words, if my line of reasoning has been correct, legal protection, with ninety per cent. of our bird species, is absolutely unnecessary, save as it applies, and then properly so, to parks, the suburbs of cities, and to logically constituted game and wild-life preserves, where shooting for *any* purpose is out of order.

Recall the geometrical ratio of reproduction, and the consequent powerful potentiality for recovery on the part of bird species. Let me cite here the case of the eastern bluebird as reviewed by Mr. P. A. Taverner in a recent number of the *Canadian Field-Naturalist* (XXXVI, April, 1922, pp. 71-72). In the winter of 1895-96 a cold wave swept the South Atlantic states, the sole wintering ground of the eastern bluebird. As a result, famine and death reduced the total bluebird population almost, but not quite, to the vanishing point. But in five years the species had recovered "from almost nothing to practical normality." After reaching normal, a "saturation point of population" for the species, it ceased to increase; or, as I would express it, its ecologic niche, of fixed amplitude, was then full. The operation of the "factor of safety" not only saved, but very quickly brought back, the species.

Another catastrophe, recorded by Dr. T. S. Roberts (*Auk,* XXIV, 1907, pp. 369-377) happened to a sparrow-like species, the Lapland longspur, in southwestern Minnesota, the middle of March, 1904. It was migration time,

and a peculiarly wet and thick snowstorm that occurred during the night of the thirteenth is thought to have overwhelmed the birds when in flight high overhead, soaking their plumage and dazing them. At any rate, great numbers hit the ground with fatal violence. In the morning dead and injured birds were to be seen over a wide stretch of country; on the frozen surfaces of two lakes 750,000 dead longspurs were counted, by the method of laying off sample units of area and checking the birds to be seen on these units. But in spite of this spectacular destruction of individuals the Lapland longspur was not reported the following years in the winter range of the species (Kansas, etc.) as obviously less numerous than usual. Did not the ability of the species to recover from this extraordinary calamity rest in the "factor of safety"?

There is good reason to believe that release of intra-specific pressure on the breeding grounds of a species is accompanied by greater productivity on the part of the remaining population. The survival chances for the young are greater where the safest type of nesting places is available to all the adults seeking to breed, and where congestion of population, and consequent drain on available food supply, has been relieved. Also, towards the end of the year, when the annual pinch of food scarcity comes into play, in the winter range, a larger proportion of maturing individuals than usual will survive. In other words, from one point of view, calamitous reduction of population benefits the immediately oncoming generations.

Let me center attention now upon the significant fact that certain of our birds are, and always have been, totally *un*protected by either law or sentiment—jays, crows, linnets, shrikes and blackbirds. The rate of annual increase in those species is no different, in so far as I am aware, than it is in the vireos, warblers, mockingbirds, tanagers, and purple finches, which latter are looked upon as desirable songbirds. Yet the former are holding their own just as well as the latter, protected, species. Their numbers are always kept up to top-notch commensurately with the prevalence of their niches. They have reached the maximum population possible to them, consistent with the nature of the country, and they hold to it.

We all know of the enmity of orchardists, and agriculturists, and sportsmen toward linnets, blackbirds and blue jays, respectively. Now and then, and there is a case on record as far back as thirty years ago, "blue jay hunts" are held; in one lately recorded instance, at Hollister, San Benito County, 1,531 California jays were killed in one day, in a prize competition for the destruction of so-called "vermin." Incidentally, you will note that sportsmen feel particular animosity toward any competitor or rival in their own field! They are right after anything that can be called "vermin" from their standpoint. As far as we can see, as a result of such campaigns—shooting of blue jays, netting of blackbirds, and poisoning of linnets—there has been only a very temporary and local reduction in the numbers of these birds; two or three seasons bring them back to normal: that is, to the maximum numbers which the amplitude of their respective niches will warrant.

Bird population, in kind and quantity, is controlled primarily by conditions of habitat. It is a matter of food and shelter. The natural history collector, as a factor against birds, is only an exceedingly minor influence, one which like all the others, is allowed for by the "factor of safety." My readers will begin to suspect that I have become sensitive because of the inveighing that certain well-meaning but uninformed people have undertaken against the killing of birds for specimens. I admit the score.

JOSEPH GRINNELL

MUSEUM OF VERTEBRATE ZOOLOGY,
UNIVERSITY OF CALIFORNIA

ARE PERMANENT DISTURBANCES OF EQUILIBRATION INHERITED?

THE writer of this note has just brought to completion a long series of studies upon the mechanics of equilibration in the white rat. During the course of these studies certain facts appeared which, though incidental to the original problem, may be of importance in the